to be attributed partly to the want of the transverse armour-plating at the extremities, and to the comparatively small number of bulkheads giving a smaller $-e$ than in the iron-plated ships of the Royal Navy, and partly to the armour-plating of the sides being continued on each side of the compass giving a large $-a$, and in this respect resembling the effect of the armour-plating in the Royal Oak class of ships in the Royal Navy.

22. The large amount of the heeling error in the Main-deck Compass and its direction is remarkable.

23. The 'Pervenetz' sailed for the Baltic on the 8th of August, 1863.

24. The only change in her magnetism on the voyage was an increase in the $+\mathfrak{C}$, which was no doubt owing to the starboard side being south.

25. The principal practical conclusions to be derived from the observations in the 'Pervenetz' seem to be,—

(1) That iron ships should be built head south.

(2) That in whatever direction an iron armour-plated ship is built, she ought to be placed in the opposite direction while plating, so as to reduce the semicircular deviation as much as possible. This results also from the observations made in the ships of the Royal Navy; but the plan of plating a ship in the opposite direction to that of building was first practised intentionally, and with the design of reducing the semicircular deviation, in the 'Pervenetz,' and, as will have been seen, with complete success.

(3) That great and rapid changes take place in the semicircular deviation some time after launching.

(4) The great amount of information both as to the semicircular deviation and the heeling error, which can be obtained by appropriate observations made while the vessel is building.

(5) The importance for this and other purposes, of reducing and recording the deviations of all iron ships, so as to obtain the values of the coefficients, and particularly λ and $\mathfrak{D}$, and to be able to estimate them in any new ship of the same class.

(6) The great importance of preparing a proper place for the reception of the Standard Compass in the construction of an iron ship.

III. "Notes of Researches on the Acids of the Lactic Series.—No. V. Action of Zinc upon a mixture of Ethyl Oxalate and Amyl Iodide." By EDWARD FRANKLAND, F.R.S., and B. F. DUPPA, Esq. Received March 30.

When a mixture of equivalent proportions of ethyl oxalate and amyl iodide is digested with granulated zinc at 70° C., the zinc is gradually dissolved, while much hydride of amyl and amylene are given off. The mixture finally assumes a viscous or semisolid condition, and, when treated with water, produces a further quantity of hydride of amyl, which distils

off at a gentle heat. On the subsequent application of a higher temperature, water, accompanied by amylic alcohol, amyl iodide, and an ethereal liquid, distils over, the three latter forming a mixture, the separation of which into its component parts presents rather formidable difficulties. After drying with chloride of calcium, this oily mixture begins to boil at about 132° C.; the product first passing over consists principally of amylic alcohol, mixed with amyl iodide. Afterwards the thermometer rapidly rises to 200° C., between which temperature and 205° C. a considerable section of the remaining liquid, which we will call A, passes over. There then occurs a further rapid rise of temperature until the thermometer remains stationary between 222° and 226°. The section collected between these points we will call B. Finally, the temperature rises to 260°–264°, between which points the remaining liquid (C) passes over. By repeated fractional distillation, the larger portion of the section A was obtained at the nearly fixed boiling-point of 203° C. This liquid was submitted to analysis, and yielded numbers closely corresponding with the formula

$$C_9\,H_{18}\,O_3.$$

Interpreted by further results detailed below, this formula resolves itself into

$$C_2\left\{\begin{array}{l} C_5\,H_{11} \\ H \\ O\,H \\ \hline O \\ OC_2\,H_5. \end{array}\right.$$

The ethereal body with the lowest boiling-point produced in this reaction is therefore *ethylic amylohydroxalate*, or oxalic ether in which one atom of oxygen is replaced by one atom of amyl and one of hydrogen. This body also stands in very close relation to lactic ether; for if the atom of methyl in lactic ether be replaced by amyl, ethylic amylohydroxalate is produced.

$$C_2\left\{\begin{array}{l} CH_3 \\ H \\ OH \\ \hline O \\ OC_2\,H_5 \end{array}\right. \qquad\qquad C_2\left\{\begin{array}{l} C_5\,H_{11} \\ H \\ OH \\ \hline O \\ OC_2\,H_5. \end{array}\right.$$

Lactic ether. Ethylic amylohydroxalate.

The two stages in the production of ethylic amylohydroxalate are explained by the following equations:—

$$C_2\left\{\begin{array}{l} O \\ O\,C_2\,H_5 \\ \hline O \\ O\,C_2\,H_5 \end{array}\right. + Zn_5'' + 4\left.\begin{array}{c} C_5\,H_{11} \\ I \end{array}\right\} = C_2\left\{\begin{array}{l} C_5\,H_{11} \\ Zn\,C_5\,H_{11} \\ O\,Zn\,C_5\,H_{11} \\ \hline O \\ O\,C_2\,H_5 \end{array}\right. + Zn\left\{\begin{array}{l} C_5\,H_{11} \\ OC_2\,H_5 \end{array}\right. + 2\,Zn''\,I_2$$

$$C_2\left\{\begin{array}{l} C_5\,H_{11} \\ Zn\,C_5\,H_{11} \\ O\,Zn\,C_5\,H_{11} \\ \hline O \\ O\,C_2\,H_5 \end{array}\right. + 3H_2O = C_2\left\{\begin{array}{l} C_5\,H_{11} \\ H \\ O\,H \\ \hline O \\ O\,C_2\,H_5 \end{array}\right. + 2\,Zn\left\{\begin{array}{l} O\,H \\ O\,H \end{array}\right. + \left.\begin{array}{c} C_5\,H_{11} \\ H \end{array}\right\} + \left.\begin{array}{c} C_5\,H_{11} \\ H \end{array}\right\}O.$$

Ethylic amylohydroxalate. Zinc hydrate. Amyl hydride. Amylic alcohol.

We have not attempted to give a name to the body from which ethylic amylohydroxalate is directly produced by the action of water, as shown in the last of the foregoing equations. The resources of chemical nomenclature, already too severely taxed, would scarcely be able to elaborate a rational name for this body, which consists of oxalic ether wherein an atom of oxygen is replaced, half by amyl and half by zincmonamyl, whilst a second atom of zincmonamyl is substituted for one of ethyl.

Ethylic amylohydroxalate is a somewhat oily, transparent, and slightly straw-coloured liquid of specific gravity ·9449 at 13° C., possessing a pleasant aromatic odour and a burning taste. It boils at 203° C., and has a vapour-density of 5·47. The above formula requires 6·0, which is removed to an unusual extent from the experimental number. To this discrepancy we shall again refer presently.

Section B of the oily liquid, after careful rectification, gave a product boiling at 224–225°, and yielded on analysis results agreeing with the formula

$$C_{11}\,H_{22}\,O_3.$$

This formula might be interpreted as that of *ethylic amyloethoxalate*, the rational formula of which would be

$$C_2\left\{\begin{array}{l} C_5\,H_{11} \\ C_2\,H_5 \\ O\,H \\ \hline O \\ OC_2\,H_5. \end{array}\right.$$

We were at first inclined to regard this as the actual constitution of the new ether, believing it to be possible that ethylic oxalate and amylic iodide mutally decomposed each other, producing a mixture of amylic and ethylic oxalates with the iodides of amyl and ethyl. An analogous decomposition of mixed ethereal salts of oxygen acids has been recently noticed, but the test of experiment obliged us to abandon this view of the reaction. We found, it is true, a remarkable depression of temperature, amounting to 9·3° C., on mixing one atom of ethyl oxalate with one of amylic iodide, but on submitting the mixture to distillation, the thermometer rose to the boiling-point of amylic iodide (147°) before ebullition commenced; thus showing that none of the much more volatile ethylic iodide had been formed. No transfer of radicals therefore takes place when ethylic oxalate is heated with amylic iodide, and consequently no zincethyl can be formed when this mixture is acted upon by zinc. We therefore prefer to view the ether now under consideration as *ethylic ethyl-amylhydroxalate*, analogous in constitution to Wurtz's ethylic ethyl lactate.

$$C_2\left\{\begin{array}{l} C\,H_3 \\ H \\ O\,C_2\,H_5 \\ \hline O \\ O\,C_2\,H_5. \end{array}\right. \qquad\qquad C_2\left\{\begin{array}{l} C_5\,H_{11} \\ H \\ O\,C_2\,H_5 \\ \hline O \\ O\,C_2\,H_5. \end{array}\right.$$

Ethylic ethyl lactate, Ethylic ethyl-amylhydroxalate.

On this view, the following equations represent the formation of this ether.

$$C_2\left\{\begin{array}{l}O\\OC_2H_5\\\hline O\\OC_2H_5\end{array}\right.+Zn''_4+4\left.\begin{array}{l}C_5H_{11}\\I\end{array}\right\}=C_2\left\{\begin{array}{l}C_5H_{11}\\ZnC_5H_{11}\\OC_2H_5\\\hline O\\OC_2H_5\end{array}\right.+Zn''\left\{\begin{array}{l}C_5H_{11}\\OC_5H_{11}\end{array}\right.+2ZnI_2.$$

Ethyl oxalate. Iodide of amyl. Zinc amylo-amylate.

$$C_2\left\{\begin{array}{l}C_5H_{11}\\ZnC_5H_{11}\\OC_2H_5\\\hline O\\OC_2H_5\end{array}\right.+2H_2O=C_2\left\{\begin{array}{l}C_5H_{11}\\H\\OC_2H_5\\\hline O\\OC_2H_5\end{array}\right.+\left.\begin{array}{l}C_5H_{11}\\H\end{array}\right\}+Zn''\left\{\begin{array}{l}OH\\OH.\end{array}\right.$$

Ethylic ethyl-amylhydroxalate. Hydride of amyl.

Ethylic ethyl-amylhydroxalate is a straw-coloured oily liquid, possessing an aromatic but somewhat amylic odour and a burning taste. Its specific gravity was found to be ·9399 at 13° C. It boils between 224° and 225° C. A determination of the sp. gr. of its vapour by Gay-Lussac's method gave the number 6·29, the above formula requiring 6·92.

Section C of the oily product, boiling about 262° C., was next submitted to investigation. It gave results on analysis agreeing well with the formula

$$C_{14}H_{28}O_3.$$

The body is therefore ethylic diamyloxalate, the normal homologue of leucic ether, as seen from the following comparison:—

$$C_2\left\{\begin{array}{l}(C_2H_5)_2\\OH\\\hline O\\OC_2H_5\end{array}\right. \qquad\qquad C_2\left\{\begin{array}{l}(C_5H_{11})_2\\OH\\\hline O\\OC_2H_5\end{array}\right.$$

Leucic ether. Ethylic diamyloxalate.

The production of ethylic diamyloxalate is explained by the following equations:—

$$C_2\left\{\begin{array}{l}O\\OC_2H_5\\\hline O\\OC_2H_5\end{array}\right.+Zn_4''+4\left.\begin{array}{l}C_5H_{11}\\I\end{array}\right\}=C_2\left\{\begin{array}{l}(C_5H_{11})_2\\OZnC_5H_{11}\\\hline O\\OC_2H_5\end{array}\right.+Zn''\left\{\begin{array}{l}C_5H_{11}\\OC_2H_5\end{array}\right.+2Zn''I_2.$$

Ethylic oxalate. Amyl iodide. Ethylic zinc-monamyl-diamyloxalate. Zinc amylo-ethylate.

$$C_2\left\{\begin{array}{l}(C_5H_{11})_2\\OZnC_5H_{11}\\\hline O\\OC_2H_5\end{array}\right.+2H_2O=C_2\left\{\begin{array}{l}(C_5H_{11})_2\\OH\\\hline O\\OC_2H_5\end{array}\right.+\left.\begin{array}{l}C_5H_{11}\\H\end{array}\right\}+Zn''\left\{\begin{array}{l}OH\\OH.\end{array}\right.$$

Ethylic zincmonamyl-diamyloxalate. Ethylic diamyl-oxalate.

Ethylic diamyloxalate closely resembles the two foregoing ethers in its appearance and properties. It is, however, a thicker oil, and flows less readily, and it has the lowest specific gravity of any ether belonging to this series, its density at 13° C. being only ·9137. The following comparison of the specific gravities of all the ethers of this series shows that they generally increase inversely as their atomic weights.

Name.	Formula.	Sp. gr.	Temp.
Ethylic lactate	$C_5\ H_{10}\ O_3$	1·042	13°
Ethylic dimethoxalate	$C_6\ H_{12}\ O_3$	0·9931	13
Ethylic ethyl lactate	$C_7\ H_{14}\ O_3$	0·9203	0
Ethylic ethomethoxalate	$C_7\ H_{14}\ O_3$	0·9768	13
Methylic diethoxalate	$C_7\ H_{14}\ O_3$	0·9896	16·5
Ethylic diethoxalate	$C_8\ H_{16}\ O_3$	0·9613	18·7
Ethylic amylhydroxalate	$C_9\ H_{18}\ O_3$	0·9449	13
Ethylic ethyl-amylhydroxalate	$C_{11}\ H_{22}\ O_3$	0·9399	13
Amylic diethoxalate	$C_{11}\ H_{22}\ O_3$	0·9322	13
Ethylic diamyloxalate	$C_{14}\ H_{28}\ O_3$	0·9137	13

Ethylic diamyloxalate boils at about 262°, and distils with little or no change. The specific gravity of its vapour was found to be only 5·9 instead of 8·4. The investigation of these ethers has revealed a tendency to dissociation increasing with the weight of the atoms replacing the atom of oxygen in oxalic ether. Thus, beginning with lactic ether, which has the normal vapour-density, we find a gradual divergence culminating in ethylic diamyloxalate, as seen from the following series of numbers:—

Name.	Formula.	Vapour-densities.	
		Calculated.	Found.
Ethylic lactate	$C_5\ H_{10}\ O_3$	4·07	4·14
Ethylic dimethoxalate	$C_6\ H_{12}\ O_3$	4·56	4·67
Ethylic ethyl lactate	$C_7\ H_{14}\ O_3$	5·03	5·052
Ethylic ethomethoxalate	$C_7\ H_{14}\ O_3$	5·03	4·98
Methylic diethoxalate	$C_7\ H_{14}\ O_3$	5·03	4·84
Ethylic diethoxalate	$C_8\ H_{16}\ O_3$	5·528	5·24
Ethylic amylhydroxalate	$C_9\ H_{18}\ O_3$	6·01	5·47
Ethylic ethyl-amylhydroxalate	$C_{11}\ H_{22}\ O_3$	6·92	6·29
Amylic diethoxalate	$C_{11}\ H_{22}\ O_3$	6·92	6·74
Ethylic diamyloxalate	$C_{14}\ H_{28}\ O_3$	8·4	5·9

We have likewise prepared the acids corresponding to the three ethers above mentioned. The first is obtained by decomposing ethylic amylhydroxalate with baryta, treating the solution of the barium-salt thus obtained with excess of sulphuric acid, and then dissolving out the organic acid with ether. On evaporating the ethereal solution, the acid remains as a thick oil which does not crystallize after several days' exposure over sulphuric acid *in vacuo*. The calcium- and barium-salts form white crystalline masses, which exhibit respectively the composition

$$C_4\left\{\begin{array}{l}(C_5\,H_{11})_2\\ H_2\\ \underline{(O\,H)_2}\\ O_2\\ {O \atop O}\,Ca''\end{array}\right. \quad\text{and}\quad C_4\left\{\begin{array}{l}(C_5\,H_{11})_2\\ H_2\\ \underline{(O\,H)_2}\\ O_2\\ {O \atop O}\,Ba''.\end{array}\right.$$

We have also obtained a beautifully crystalline acid of the same composition, and perfectly pure, from its zinc-salt, which is contained in the residue remaining after the distillation of the three ethers above described. *Amylhydroxalic acid* prepared from this zinc-salt is but sparingly soluble in water, from which, however, it crystallizes in magnificent nacreous scales that fuse at 60°·5 C., but afterwards remain liquid for some time even at ordinary temperatures; they are very unctuous to the touch, and readily soluble in alcohol and ether. Several analyses gave results closely corresponding with the formula

$$C_2\left\{\begin{array}{l} C_5\,H_{11}\\ H\\ O\,H\\ \hline O\\ O\,H.\end{array}\right.$$

The barium-salt of this acid crystallizes in large and beautiful nacreous scales like paraffin, tolerably soluble in water, and exhibiting the composition

$$C_4\left\{\begin{array}{l} (C_5\,H_{11})_2\\ H_2\\ (O\,H)_2\\ \hline O_2\\ \begin{array}{l}O\\ O.\end{array}Ba''\end{array}\right.$$

We have also prepared a copper salt which is deposited from its aqueous solution in the form of minute light-blue scales, very sparingly soluble in water. The numbers obtained by the analysis of this salt agree with the formula

$$C_4\left\{\begin{array}{l} (C_5\,H_{11})_2\\ H_2\\ (O\,H)_2\\ \hline O_2\\ \begin{array}{l}O\\ O.\end{array}Cu''\end{array}\right.$$

By the decomposition of ethylic ethyl-amylhydroxalate with alcoholic potash, subsequent addition of sulphuric acid in excess, and treatment with ether, the corresponding acid was obtained as a thick oil, gradually solidifying to a crystalline mass, which, however, did not appear to be in a fit state for the determination of its fusing-point. We have examined the barium- and silver-salts of this acid, which have respectively the following composition:—

$$C_4\left\{\begin{array}{l} (C_5\,H_{11})_2\\ H_2\\ (O\,C_2\,H_5)_2\\ \hline O_2\\ \begin{array}{l}O\\ O\end{array}Ba''\end{array}\right. \quad \text{and} \quad C_2\left\{\begin{array}{l} C_5\,H_{11}\\ H\\ OC_2\,H_5\\ \hline O\\ O\,Ag\end{array}\right.$$

Barium ethyl-amylhydroxalate. Silver ethyl-amylhydroxalate.

Ethylic diamyloxalate is readily decomposed by baryta-water. After removing the excess of baryta in the usual manner, barium diamyloxalate

crystallizes on evaporation in minute elastic needles, which, when dry, have the appearance of wool. It is moderately soluble in hot water, but sparingly so in cold. This salt gave numbers on analysis closely corresponding with the formula

$$C_4\left\{\begin{array}{l} (C_5H_{11})_4 \\ (OH)_2 \\ \hline O_2 \\ O \\ O.Ba'' \end{array}\right.$$

If barium diamyloxalate be dissolved in hot dilute alcohol, and excess of sulphuric acid be added, the liquid after filtration contains diamyloxalic acid in solution. On heating upon a water-bath, the alcohol gradually evaporates, and diamyloxalic acid crystallizes in the hot solution as a beautiful network of brilliant silky fibres, which, after being well washed in cold water and dried at 100°, yielded on analysis numbers closely corresponding with the formula

$$C_2\left\{\begin{array}{l} (C_5H_{11})_2 \\ OH \\ \hline O \\ OH. \end{array}\right.$$

Diamyloxalic acid presents the appearance of colourless satiny fibres, which are insoluble in water, but soluble in alcohol and ether. This acid is remarkable for its high melting-point, 122° C., in which respect it surpasses any of the acids of this series. Its melting-point is very sharply defined, and it solidifies immediately on a very slight reduction of temperature. Heated more strongly, it sublimes and condenses on a cold surface in white crystalline flakes like snow.

No. VI. *Action of Zinc upon Amylic Oxalate and Ethylic Iodide.*

Equivalent proportions of amylic oxalate and ethylic iodide were digested at 50° to 60° C., with excess of granulated zinc, for several days. The reaction proceeded with extreme sluggishness, and was not completed before the expiration of a week. Being then mixed with water and submitted to distillation, an oily liquid passed over, which, on rectification, was ultimately resolved into amylic alcohol and an ethereal liquid, which analysis proved to be *amylic leucate.*

The two consecutive reactions by which this body is produced are expressed in the following equations:—

$$C_2\left\{\begin{array}{l} O \\ OC_5H_{11} \\ \hline O \\ OC_5H_{11} \end{array}\right. + Zn_4'' + 4\left.\begin{array}{c} C_2H_5 \\ I \end{array}\right\} = C_2\left\{\begin{array}{l} (C_2H_5)_2 \\ OZnC_2H_5 \\ \hline O \\ OC_5H_{11} \end{array}\right. + Zn\left\{\begin{array}{l} C_2H_5 \\ OC_5H_{11} \end{array}\right. + 2ZnI_2.$$

Amylic oxalate. Amylic zincmonethyl leucate. Zinc ethylo-amylate.

$$C_2\left\{\begin{array}{l} (C_2H_5)_2 \\ OZnC_2H_5 \\ \hline O \\ OC_5H_{11} \end{array}\right. + 2H_2O = C_2\left\{\begin{array}{l} (C_2H_5)_2 \\ OH \\ \hline O \\ OC_5H_{11} \end{array}\right. + \left.\begin{array}{c} C_2H_5 \\ H \end{array}\right\} + Zn\left\{\begin{array}{l} OH \\ OH. \end{array}\right.$$

Amylic zincmonethyl leucate. Amylic leucate.

Amylic leucate is a colourless, transparent, and slightly oily liquid, possessing a fragrant odour of a somewhat amylic character. It is insoluble in water, but miscible in all proportions with alcohol and ether. Its specific gravity is ·93227 at 13° C. It boils constantly at 225° C., and its vapour has a density of 6·74 (theoretical 6·97).

The boiling-point and specific gravity, in the liquid form, of amylic leucate and its isomer, ethylic amylethoxalate, are almost absolutely identical. Leucate of amyl is readily decomposed by either aqueous or alcoholic solutions of the alkalies, or by baryta-water, yielding amylic alcohol and a leucate of the base.

No. VII. *Action of Zinc upon a mixture of Amyl Oxalate and Amyl Iodide.*

When equivalent proportions of the amyl iodide and amyl oxalate are heated gently in contact with zinc, a brisk reaction soon sets in. After evolving much hydride of amyl and amylene, the whole solidifies to a gum-like mass, which, on distillation with water, yields an oily liquid resembling that obtained when ethyl oxalate is employed. We have every reason to believe that the same series of ethers as those described in note No. V. are here produced, with the difference that they are amylic, instead of ethylic ethers. This difference of base, however, renders it impossible successfully to separate these ethers from each other, their boiling-points being so high as to determine decomposition when their distillation is attempted. We might, it is true, have decomposed the mixed ethers with solution of baryta, and thus have obtained the mixed acids, but the task of disentangling the latter appeared also so hopeless, that we have not attempted it.

IV. "Notes of Synthetical Researches on Ethers.—No. I. Synthesis of Butyric and Caproic Ethers from Acetic Ether." By EDWARD FRANKLAND, F.R.S., and B. F. DUPPA, Esq. Received April 5, 1865.

For some time past we have been engaged in the study of the consecutive action of sodium and the iodides of methyl and ethyl upon acetic ether. When iodide of methyl is used, the chief products of the reaction are two ethereal bodies possessing respectively formulæ, which we will provisionally write as follows:—

$$\left.\begin{matrix} C\ O'' \\ C_4\,H_7 \\ C_2\,H_5 \end{matrix}\right\} O_2 \quad \text{and} \quad \left.\begin{matrix} C\ O'' \\ C_5\,H_9 \\ C_2\,H_5 \end{matrix}\right\} O_2.$$

These bodies are decomposed, even in the cold, by baryta-water, yielding barium carbonate, alcohol, and two new ethereal liquids having formulæ which, without expressing any opinion as to their nature or constitution, may be thus written:—